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TECHNICAL ASPECTS OF THE 1934 INTERNATIONAL TOURING COMPETITION (RUNDFLUG)

By R. Schulz and W. Pleines

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I. INTRODUCTION

The rules and regulations governing the International Touring Competition of 1934 favored in particular those airplanes which proved superior in performance from various points of view rather than from one particular aspect. The donor had worked out such an elaborate point-score system for certain characteristics and performances, that the designers were practically forced to produce what might be called an ideal type of airplane. Thus, apart from the limitation of the tare weight to 560 kg (1,235 lb.), the choice of the designer was automatically very much restricted.

The contest comprised:

a) Stalling-speed tests - with 75 k.p.h. (46.6 m.p.h.) as upper limit; that is, speeds higher than 75 k.p.h. were not rated, while every 0.25 k.p.h. (0.16 m.p.h.) less than 75 k.p.h. (46.6 m.p.h.) scored 1 point.

b) Take-off and landing tests.- In the take-off tests, take-off runs - over a 26.2-foot obstacle - of more than 820 feet were not rated, while the competitor was awarded 4 points for every 5 m (16.4 ft.) less than this distance. Similarly, landing runs of more than 820 feet were not counted, but the competitor was awarded 6 points for every 16.4 feet less than this distance. Four attempts were allowed for each of these trials.

c) Fuel-consumption tests over a course of approximately 600 km (373 miles).- The maximum consumption had been fixed at 20 kg per 100 km (71 lb. per 100 miles),

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*"Technischer Rückblick auf den Internationalen Rundflug 1934." Luftwissen, September 15, 1934, pp. 244-257, and October 15, 1934, pp. 288-290.

while every kilogram less than this figure was rated at 10 points. The speed maintained during the consumption test was counted in the rating of the average speed of the distance flight.

d) Engine starting test.- Engine starting was rated according to type of starting system, the most perfect method, namely, by switch from the cockpit being awarded a maximum of 24 points. The starting time was not to exceed 2 minutes; otherwise the competitor was penalized 50 percent of his obtained number of points. If the starting time exceeded 10 minutes, he was in any case awarded 0 points.

e) Wing - folding and extension test.- Every competing airplane had to be dismantled so as to pass through a door 14.7 feet wide and 11.5 feet high. The method of assembly and disassembly through folding the wings by rotation about several axes, was rated with 6 points. Folding by means of rotating the wings about one axis was rated at 12 points. The maximum number of points for folding and unfolding up to 1 minute, was 12 points. For the time in excess of 1 minute, the competitor received correspondingly fewer points; for the time beyond 9 minutes and up to 20 minutes, he received 0 points, and for that above 20 minutes, he was penalized. The width of the folded airplane also was rated.

f) Rating of technical characteristics.- The rating of the equipment comprised about 1/3 of the total number of points. The maximum number of points awarded were:

1. For view from the pilot's seat	50
For view from the passenger's seat	25
2. Safety devices:	
a) Antistalling devices, such as slots and flaps	30
b) Compression-ignition engines	60
3. Load-trimming devices	20
4. Good arrangement of the instruments	30
5. Metal construction:	
a) Fuselage	20
b) Wings, covering	12
c) Tail surfaces, covering	8

6. Comfort: adjustable seats, adjustable rudder bar, arm rests, accessibility, heating, ventilation, etc. 50

7. Cabin for whole crew 30

8. Emergency exits 20

9. Side-by-side seating 35

10. Third comfortable seat.......................... 100

11. Fourth comfortable seat......................... 16

12. Fire protection in excess of the stipulated requirements 10

13. Landing gear.................................... 8

14. Tail skids, tail wheels which do not damage the landing field 4

15. Dual control, detractable 8

16. Night lighting for 3 hours 4

17. Special installations 20

g) Distance flight.- Ratings were given for regularity and average speed.

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The lowest average speed, below which the competitor had to withdraw from the race, was 135 k.p.h. (83.8 m.p.h.). Average speeds between 140 and 190 k.p.h. (86.9 and 118.0 m.p.h.) were rated with 12 points; those between 190 and 200 k.p.h. (118 and 124 m.p.h.) with 8 points; and those between 200 and 210 k.p.h. (124 and 130 m.p.h.) with 4 points for every kilometer per hour. Average speeds in excess of 210 k.p.h. were not rated, nor were speeds of more than 15 k.p.h. higher than those flown during the fuel-consumption test.

h) Maximum speed test.- over a course of approximately 300 km (186.4 miles). Every kilometer per hour above 210 was rated at 1 point. There was no upper limit.

II. THE ENTRIES

Every one of the 34 entries save one (the D.H. "Puss Moth") had been specially designed for this contest. The entries were:

3 BFW Me 108 with HM 8U Hirth engine.

1 BFW Me 108 with As 17 Argus engine.

3 Fieseler Fi 97 with HM 8U Hirth engine.

2 Fieseler Fi 97 with As 17 Argus engine.

2 Klemm Kl 36 with HM 8U Hirth engine.

2 Klemm Kl 36 with As 17 Argus engine.

5 PZL 26 with Menasco Buccaneer B6 S3 engine.

4 RWD 9 with Gr.760 Skoda engine.

3 RWD 9 with Walter Bora engine.

2 Aero A 200 with Walter Bora engine.

2 Breda BA 42 with A 70S Fiat engine.

2 Breda BA 39S with S 63 Colombo engine.

2 Bergamo PS 1 with A 70S Fiat engine.

1 D.H. "Puss Moth" with D.H. Gipsy Major engine.

A brief description of these airplane types follows:

<u>BFW Me 108</u>.- Designed by the Bavarian Airplane company (Messerschmitt) (see figs. 1a and 1d), it is a four-place, all-metal (duralumin), low-wing monoplane fitted with slots and flaps. The single-spar wings are readily folded by removal of the pins by means of a lever. The fuselage is of the monocoque type; the upper part of the cabin, formed of steel tubing, is fitted with emergency doors. Both front seats are fitted with controls. The tail is all-metal, the stabilizer adjustable in flight. The landing gear is completely retractable. Each half comprises two cantilever oleo legs which fold in the wing

by means of a crank and a simple worm drive (fig. 1b). An optical and acoustic signal, released when the gas throttle is set to idling, warns the pilot when ready to land. The wheels are fitted with compressed air brakes operated by hand grip on the control stick.

Fieseler Fi 97.- This also is a four-place, low-wing cabin monoplane (figs. 3a to 3c). The wing is in three parts; the center section, of steel tubes, is bolted to the fuselage while the wings proper (of single spar and a false spar) are of wood. It represents a special design with slots and Fowler-type wing.

The fuselage is a fabric-covered truss of welded steel tubes. Great attention was paid to the cabin appointments which include among others, an automatic fire alarm and a ventilation system. The sliding roof assures easy accessibility. The front seats have interconnected dual controls. The wooden stabilizer is adjustable in flight individually or in conjunction with the auxiliary wing. Elevator and rudder consist of a light metal frame with fabric covering, while the fin structure is of steel tubing. The landing gear is of the three-strut type, the oleo-pneumatic shock absorber being formed by the main strut.

Klemm Kl 36.- This is a four-place, cantilever, low-wing cabin monoplane (figs. 2a and 2c). The wing is fitted with slots and trailing-edge flaps. Its construction follows the conventional practice of two spars and plywood covering. The fuselage frame is of welded steel tubes covered with fabric. The cabin is accessible by means of the hinged left-side wall and the roof. In case of emergency, the whole top is detachable. The front seats are fitted with interconnected dual controls; the stabilizer is adjustable in flight. The landing gear is partly braced and partly with cantilever oleo legs. The wheels are equipped with internal expanding brakes.

RWD 9.- Built by Rogalski, Wigura and Drzewiecki in Okecie near Warsaw, this airplane (figs. 4a and 4b) is very much like the RWD 2, the winning entry in the 1932 race. The principal modifications were made on the wing structure which is now designed with two spars instead of one, covered with fabric. Like its predecessor, it has slotted wings and trailing-edge flaps. The wings can be folded. The fuselage is of welded steel tubing with fabric covering. The cabin seats four (two seats side by side), and has two doors which also serve as emergency exits. Dual control, detachable. The tail surfaces are welded steel-tube structures covered with fabric. The landing gear, of the pyramid type, comprises oleo-pneumatic shock absorbers and wheel brakes.

PZL 26.- This is a scaled-up version of the PZL 19 of 1932, designed in the Polish State Airplane factory (Panstwowe Zaklady Lotnicze). It is a three-place, cantilever cabin monoplane of metal construction (figs. 5a and 5b). The wing, also covered with light metal, is fitted with slots and split trailing-edge flaps and can be folded. The fuselage provides for row seating, so as to keep the diameter to a minimum. Dual control, detachable cabin cowl. The fuselage is of welded steel tubes covered with fabric, as are the tail surfaces. The landing gear is of the cantilever type; the wheels are fitted with brakes and carefully faired in.

Aero A 200.- This airplane, designed by the Czechoslovakian airplane firm Aero, may be looked upon as a new version of their 1932 entry (figs. 6a and 6b). It is a braced low-wing cabin monoplane. The wing is of the two-spar type, covered with fabric, foldable, and fitted with slots and trailing-edge flaps. The fuselage, of welded steel tubing, is fabric-covered. The cabin, with dual control, seats four. The landing gear consists of oleo legs and wire bracing. Wheel brakes are provided.

Breda BA 39S.- This is the modified BA 39 of the 1932 race (figs. 7a and 7b). A braced low-wing monoplane, it has a third seat (one behind the other) and a new wing type of structure (Breda-Mazzini slotted wing). In front of the ailerons and the flaps is a form of slot known as the Breda-Mazzini wing valve, on the development of which the company has been working for ten years. These are passages right through the wings, whose lower openings are closed by movable sections of the wing. The wing is of wood, has two spars, and is covered with fabric. The fuselage is of steel tubes covered with fabric. The cabin fairing is in three pieces, hinged to serve as entry. The tail surfaces also are of steel tubes with fabric covering. The landing gear is of the independent faired type with long-travel shock absorbers and wheel brakes.

Breda BA 42.- This is a scaled-up version of the BA 39S but with a different airfoil section and bracing system (figs 8a and 8b). The fuselage has a low cabin fairing and three seats, one behind the other. The fuselage shape is aerodynamically superior to the BA 39S, owing to the round section of plywood in front (to conform to the Fiat radial engine) and its oval shape in the rear. The tail surfaces are of wood with fabric covering, with the exception of the rudder which is of welded steel tubing. The landing gear is similar to that on the 39S.

Bergamo PS 1.- Designed by the Cantieri Aeronautici Bergamaschi as a four-place, low-wing, cabin monoplane (figs. 9a and 9b), the wing structure is of metal, of the single-spar type and fitted with slots; spar truss and ribs are of welded steel tubes. The fuselage and the tail surfaces are also of steel tubes covered with fabric. The landing gear is partially retractable rearward into the wing.

D.H. "Puss Moth".- This is a three-place, braced, high-wing cabin monoplane of well-known design, which was converted to conform to the rules of the race. It was fitted with full-span slots and flaps next to the fuselage.

Power plants.- The regulations stipulated no limitations as to performance, displacement, etc. On the other hand, the designer was forced to select an engine of maximum output in order to remain within the prescribed limit of 560 kg (1,234.59 lb.) tare weight. Poland was the only country which concentrated on a special engine design, since it naturally desired to provide a power plant of national make. For the rest, the airplane designers should have had no special difficulties in selecting a suitable engine from among those available.

Argus As 17.- This is a development of the well-known As 8 and As 8R to a 6-cylinder engine.

Hirth HM 8U.- This is a modern version of the HM 150 and was much preferred by the German constructors because of its compactness and high performance.

Airplanes Entered in the 1934 International Touring Competition

Make	Type[1]	Material[2]: Wing and frame covering	Material[2]: Fuselage and frame covering	Engine	Horsepower[3]	Length m	Span m	Wing area[4] m^2	Structural weight kg	Flight weight kg	Wing loading kg/m^2	Power loading kg/hp	hp/m^2	Remarks
BFW Me 108	T	L-L	L-L	Hirth HM 8U	225	8.06	10.31	16.0	560	1050	65.6	4.7	14.1	Retractable landing gear
				Argus As 17	210		10.31	16.0	560	1050	65.6	5.0	13.1	
Fieseler Fi 97	T	H-H	St-S	Hirth HM 8U	225	8.04	10.7	15.3	560	1050	68.7	4.7	14.7	
				Argus As 17	210	8.24	10.7	15.3	560	1050	68.7	5.0	13.7	
Klemm Kl 36	T	H-H	St-S	Hirth HM 8U	225	9.2	11.0	19.5	560	1050	53.8	4.7	11.5	
				Argus As 17	210	9.2	11.0	19.5	560	1050	53.8	5.0	10.8	
PZL 26	T	L-L	St-S	Menasco B6 S-3	265	7.5	10.42	16.34	560	1050	61.5	4	16.2	
RWD 9	aH	H-S	St-S	Skoda Gr. 760	260				560	1050		4		
				Walter Bora	200				560	1050		5.2		
Aero A 200	vT	H-S	St-S	Walter Bora	200	7.8	11.1	16.58	560	950	57.2	4.8	12.1	
Breda BA 39S	vT	H-H	H-H	Colombo S 63	150				550					
Breda BA 42	vT	H-H	St-H	Fiat A 70 S	200	7.8	10.1	15.8	560	910	57.6	4.6	12.7	
Bergamo PS 1	T	St-S	St-S	Fiat A 70 S	200	7.19	10.67	17.55	560	1050	59.9	5.3	11.4	Retractable landing gear
D.H. "Puss Moth"	aH	H-S	H-H	D.H. Gipsy Major	120				560	930				

[1]T, cantilever low-wing monoplane; vT, braced low-wing monoplane; aH, braced high-wing monoplane.

[2]L, light metal; St, steel; H, wood; S, fabric.

[3]Maximum performance (see table, page 9).

[4]Small area of airplanes having variable wing area.

Engines in the 1934 Touring Competition

Make	Cylinder		Rated		Maximum		Gear ratio	Bore	Stroke	Displacement	Compression ratio	Weight, dry[1]	Weight/hp.[2]	hp/liter[2]	Remarks
	No.	setting		crank-shaft		crank-shaft									
			hp.	r.p.m.	hp.	r.p.m.		mm	mm	liter		kg	kg/hp		
Argus As 17A	6	In-line, inverted	210	2400			–	120	130	8.82	6.3	160			
Hirth HM 8U	8	V, in-verted	225	3000			3:2	105	115	7.99	6.5	153			
Skoda Gr.760	9	Radial			270	3200	3:2			9		148	0.55	30	Booster (data doubtful)
Walter Bora	9	Radial	200	2150	220	2300	–	105	120	9.35	6.3	165	0.75	23.5	Booster
Fiat A 70 S	9	Radial	186	2100	200	2300	–	115	115	8.36	5.8	162	0.81	23.9	Booster
Colombo S63	6	In-line	135	1700	150	2000	–	114	140	8.57	5.2	151	1.0	19.5	
Menasco Buc-caneer B6 S-3	6	In-line, inverted			265	2500	–	114	130	8.03		178	0.67	33.0	Supercharger (data doubt-ful)
D.H. Gipsy Major	4	In-line, inverted	120	2100	130	2350	–					136	1.05		

[1]Dry weight without propeller hub. [2]Referred to maximum performance.

III. SPECIAL AERODYNAMIC DETAILS

By virtue of the enlarged regulations from the point of view of flight performances, the demands on the airplanes and their aerodynamic features have increased enormously. On examination of this year's entries and comparison of the performances obtained with these airplanes, it is readily seen that the technical tests of the circuit flight have grown far beyond the original (1929) purpose.

The primary purpose is the promotion of greater safety. From the performances at high angles of attack is demanded: great gliding angle with low flight speed and no unduly high sinking speed to assure short taxying runs. This is closely bound up with the safety requirements. For, in order to take full advantage of the highest attainable angles of attack (minimum speed, stalled landing), the airplane must be adequately stable and controllable about every axis, especially about the longitudinal. Safe flight at high angles of attack is contingent upon adequate roll stability and lateral controllability. Admittedly, no definite lucid representation about the lower limit of the performance requirements (minimum speed, maximum gliding angle, etc.) and characteristics has been found heretofore. Besides, for the present, it is, and will continue to be, difficult to establish suitable values for it. As to the value of the practical proof and demonstration of the quality of airplanes within the scope of such technical tests (as, say, of the take-off and landing tests), one may have different opinions. But one thing is certain: They have not hindered progress.

Practically every designer had spared no energy nor pains to further aerodynamic progress in the desired direction. The lessons of the 1932 circuit flight were kept well in mind as proved by this year's results. Some of the types revealed no change in design and shape, and presented simply logical improvements of previous race entries. The designers of these airplanes have intentionally refrained from producing fundamentally new designs.

In this category belong the RWD 9, PZL 26, Aero A 200, Klemm Kl 36 and, to a certain extent, the Breda 39 and 42. Of the known aerodynamic auxiliaries used, there were: the Handley Page-Lachmann slotted wing, predominantly the auto slot; then, trailing-edge flaps and split flaps, operated mechanically from the pilot's seat or automatically in combinations. (See fig. 10.)

The second group of airplanes comprises airplanes embodying new features or at least auxiliary means not previously tried out on such a large scale. To these belong in particular, the German types BFW Me 108 and the Fieseler Fi 97. Unfortunately, the lack of time made it impossible to subject these airplanes to exhaustive tests before the race, so that the performances obtained in the contest are not directly comparable with those of other types (RWD 9 and PZL 26), which had months to try them out.

The Me 108 and Fi 97 also have wing slots but specially designed trailing-edge flaps. They are so designed that when the flap is deflected the camber, as well as the wing area, is increased chordwise. Thus the flap - formed as special auxiliary wing - rolls out and down. This method appears particularly promising because then the wing area is small conformable to the conditions at high speed, but substantially greater at low speed, take-off, and landing. On the other hand, it must not be forgotten that this method presents considerably more difficult problems for the designer than is generally assumed. The structural aspect itself of the movable parts, the stresses acting upon them, especially when coupled with a slotted wing, present exceedingly involved problems. It is therefore a pleasure to be able to state that fundamentally all problems have been solved even if there is room for further improvement.

Klemm Kl 36.- The aerodynamic aspect of the wing (fig. 2c) is the same as that of the tried and proved Heinkel He 64, used in the preceding international circuit competition. The full-span slotted wing (Handley Page-Lachmann type) is divided; the outer part (wing-tip slot) is coupled to the aileron so that by automatic opening, the aileron assumes a new downward neutral setting. The inner slot is coupled to work with the trailing-edge flap in such a way that upon opening the flap is set downward. Both can be locked in neutral, open, or down setting.

The wing flap extends as far as the aileron and forms with (35° maximum downward) setting a slot. The lateral control is by conventional ailerons. The race has shown this combination of slot and flap to be aerodynamically very satisfactory, which likewise is in accordance with the practical experience gained on other airplane types.

PZL 26.- This airplane features a full-span divided slotted wing (Handley Page-Lachmann). The outer part, the wing-tip slot, is automatic; the inner part is linked to the trailing-edge flap and operated mechanically from the pilot's seat. The flap is of the split type (fig. 11). To prevent premature and accidental closing, the wing-tip slot is fitted with a safety device similar to that on the BFW Me 108 (figs. 15 and 16).

Originally the lateral control was to be by means of interceptors instead of the customary ailerons, and preliminary tests had proved their feasibility, but the designer hesitated to use them on a racing airplane so long as all problems had not been definitely cleared up. The aerodynamic characteristics of this airplane are extremely satisfactory but it develops flutter in the longitudinal and vertical tail surfaces at high angles of attack (low speed). As the split flap is mounted close to the fuselage, any great flap deflection produces severe downwash changes and a periodically changing impact-like load on the tail as a result of a considerable vortex formation. A low-wing monoplane should therefore have the split flaps not quite so close to the fuselage; at least it appears that caution is in place.

RWD 9.- Excepting minor modification, the aerodynamic aspect of this airplane is the same as that of its predecessor, the RWD 6. The wing is fitted with continuous Handley Page auto slots and simple trailing-edge flaps (fig. 12), operated from the pilot's seat (maximum down setting 20°).

To improve lateral controllability, the conventional ailerons - differential type - are linked with an additional lateral control by means of interceptors. The latter (of about 0.8 m (2.62 ft.) length) lies on the upper surface of the wing ahead of the ailerons, but is not covered by the slotted wing (i.e., it acts at low angles of attack with slot closed). The remarkable effectiveness of this lateral control, in spite of ample damping in roll, was plainly in evidence at all flights with high angles of attack (minimum speed, stalled landing).

Aero A 200.- Its aerodynamically very propitiously designed wing was fitted with slots and flaps (fig. 13). The slotted wing can be locked in either open or closed position (compare the Klemm Kl 36). This possibility obviates the danger of uneven opening or closing in stalling flight during rough weather. The torque shaft links the slots of the two wing halves very rigidly, thus insuring even and simultaneous opening and closing at all times. This point has frequently proved a source of disturbance in other airplanes (which, as a rule employed slide-rail guidance and rollers, and which resulted in unequal bearing friction, due to poor workmanship). The customary trailing-edge flap on the inside is linked with the slotted wing (maximum down movement 45°), as are the ailerons which can be set down in a second neutral position (15°).

The lateral control is connected to a Handley Page-Lachmann interceptor control by means of conventional ailerons. The interceptor becomes effective only after the slots are open, and in such a way that the interceptor operates only upwardly when the aileron is deflected (fig. 14).* According to preliminary experiments the arrangement of the interceptor extending as far as the wing tip produced a sudden loss of damping in roll and suddenly incipient rolling motions. As a result, the interceptor was shortened about 1 meter from the wing tip over a span distance of 0.8 m (2.62 ft.). The combination aileron-interceptor gave the airplane a remarkable lateral controllability, especially at high angles of attack. This arrangement is perhaps the most appropriate and practically the most reliable solution at the present time.

BFW Me 108.- This airplane presents a remarkable and novel form of development from the aerodynamic point of view. It has a full-span, divided slotted wing, The outer part, the wing-tip slot, is automatic at any attitude for the purpose of assuring adequate damping in roll; the inner part is connected to the landing flap and operated conjointly by hand wheel from the pilot's seat. The flap, extending over the span - save for a small strip about 0.3 m wide at the wing tip, which forms the aileron - follows the basic profile when closed, and simultaneously pushes rearward with increasing setting (maximum down deflection 31°) (fig. 15a) so as to form a slot between wing and landing flap. This increases the wing area by about 1.2 m, or 8 percent.

A simple locking device prevents the outer slot from closing more than the inside slot (to prevent sideslipping). The original intention was to use only one lateral control by means of interceptor located behind the wing slot, which had proved very satisfactory on another type.

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*Pleines, W.: Der Schlitzflügel. Luftwissen, vol. 1, no. 7, 1934, p. 194.

But lack of time for exhaustive trials before the race finally caused the designers to add a very small normal aileron directly at the wing tip and to connect it with the interceptor (fig. 15b). This combination has proved quite effective. Still it presents only a temporary solution. The final design is held in abeyance until after the race.

Fieseler Fi 97.- This airplane presents some new departures in aerodynamic design. The wing is fitted with Handley Page-Lachmann auto slots, extending over about 0.55 m (1.80 ft.) of the semispan. The original intention was to have only a wing-tip slot of 0.4 over the semispan, but this was found to be insufficient for maintaining adequate lateral stability (strongly trapezoidal wing contour). Lack of time then resulted in the fitting of a temporary inner portion (slotted wing without special form). However, the tip of the slotted wing is unlike that which English tests had shown to be favorable.

In addition, the airplane was fitted with a Fowler-type auxiliary wing, which rolls out and down and at the same time increases the wing area (~ 2.8 m (9.19 ft.) = ~ 18 percent) in chord direction (figs. 16 and 17). It also forms a slot between the normal wing trailing edge and the auxiliary wing. U. S. wind-tunnel tests on the Fowler wing manifested very high maximum lift coefficients which, referred to the original wing area, amount to about 3.15 and together with slotted wing, to about 3.60. It was also found that the $c_{a_{max}}$ for the wing with extended and retracted auxiliary wing lies at approximately the same angle of attack, which likewise is propitious for the landing conditions. Admittedly, there is a very abrupt drop in lift after reaching $c_{a_{max}}$. For that reason the addition of wing-tip slots with the object of maintaining adequate lateral stability in stalling appears particularly appropriate.

As the flap continues along the span a special type of aileron, similar to a split flap, was used rather than the conventional aileron. The ailerons deflect only upward (fig. 18) and, specifically, only at the side of the wing where a down motion of the wing is to be initiated. With flap retracted the aileron acts almost exclusively as split flap, although with lateral control movement a backward aileron movement is also initiated because of the fact that its center of rotation lies far above it. Contrariwise, with flap extended, an upward lateral control movement produces at the same time a slot in width corresponding to the deflection, which enhances the effectiveness of this lateral control considerably at high angles of attack, while of course vitiating the aerodynamic characteristics of the wing at this point with large aileron deflections (abnormal enlargement of slot between wing and flap).

Breda BA 39S and BA 42.- On these two types the use of slotted wings, so successfully employed on the previous B 33 entries, has been abandoned in favor of a multiply divided, fixed slot before the aileron and the simple, manually operated landing flap. This slot (figs. 19 and 20) (Breda-Mazzini call it "wing valve") is closed at high-speed flight through a special shuttering device on the bottom side and opened by hand at high angles of attack. This initiates a secondary flow from the lower toward the upper surface, while at the same time a light effect similar to that produced by a split flap, is obtained through the opening of the shutter mechanism on the lower surface. Judged by the results of the stalling-speed test, the effectiveness of this slot is not very apparent. Besides, the confidence of the crew in the effectiveness of this arrangement did not seem to be very great. An examination on the Breda entries which landed during the distance flight in Berlin, revealed that the shutter device had been specially locked from the outside, hence precluded any chance of opening in flight from the pilot's seat. Lack of lateral controllability also appears to be the reason for the poor showing of the BA in the cited test.

IV. RESULTS

Naturally, the results of this contest cannot be compared by the same standard as is normally done in performance trials, because of the inevitable factor of chance involved in contests of this kind. But it is possible at any rate, to trace the development of a certain group of airplanes within the last few years.

The design of new racing airplanes is governed by the contest regulations which in their multiplicity admit naturally of different interpretations and consequently of different solutions. The performance of an airplane is contingent upon a number of factors (wing loading, power loading, wing power, span, maximum lift) which, apart from the structural design, characterize the aerodynamic quality and afford serviceable comparative data for power absorbed and power required. As the comparison here pertains to a group of similar airplane types employed for the same purposes and of similar design and construction, which were subjected to the same tests, the comparison should at least be useful for statistical considerations. Moreover, the comparison will have to be limited to the speed trials because in these alone the element of chance is to some extent absent, even though the personal factor helps in deciding the performance of the airplane. The results of previous contests have been included.

One of the first questions to decide was, the line of attack followed to meet the maximum speed requirements, that is, the auxiliary means with which it was at all possible to increase the maximum speed v_{max}.

The contributing factors in v_{max}* are the power loading G/N and the wing power N/F. Figure 21 shows v_{max} plotted against G/N for the majority of this year's race entries, as well as those of previous contests, for which the requirements and structural problems were at least very similar, if not exactly the same. The shape of the two boundary curves for the aerodynamic quality factor k_1 (1050-1700) discloses the law according to which the power loading of an airplane must be reduced, in order to insure higher maximum speed without altering the aerodynamic quality (k_1 = constant). Thus the numerically higher k_1 defines the higher aerodynamic figure of merit. In the same manner as in past years of the contest,

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*According to the initial conditions for level flight at constant height (thrust = drag) v_{max} is dependent on the power loading G/N and unaffected by changes relative to the size of the wing area. The equation is:

$$v_{max} = 75\ \eta\ \frac{N}{G} \left(\frac{c_a}{c_w}\right)_{max}$$

The division of aerodynamic and weight factors gives: $v_{max} = k_1 \frac{1}{G/N}$. Factor k_1 contains, aside from the propeller efficiency η, the value $\left(\frac{c_a}{c_w}\right)_{max}$, that is, the best lift/drag ratio, and determines in first approximation the aerodynamic quality.

the higher maximum speed of most airplanes was attained without special improvement of the aerodynamic quality but rather by decreasing the power loading; or, in other words, by the use of more powerful engines. The entries of the first few races manifested, in part, a higher aerodynamic figure of merit ($k_1 = 1700$) because they had been developed from aerodynamically excellent sailplanes, although their practical value, measured by modern standards, was comparatively small. For the majority of this year's entries the k_1 factor leans more toward the lower boundary, ranging between 1000 and 1200. (See table I.) With its substantially higher values of 1400 to 1450, and consequently higher speed values for equal power loading, the BFW 108 is noteworthy. As to the individual measures for lowering the power required and thereby for promoting higher aerodynamic quality, we refer to a subsequent chapter. But in all other respects, the developments followed identically the same direction as the preceding years.

In Figure 22, v_{max} is shown against N/F,* with different figures of merit k_2. The shape of the curve shows the law according to which v_{max} may be raised with an increase in N/F without changing the figure of merit (k_2 = constant).

Whereas in last year's contest a sudden improvement in aerodynamic quality along with a modest increase in N/F had been attained, the line of attack followed this year was, without a doubt, the more simple, namely to obtain a higher maximum speed (admittedly, only within a limited range, as seen from the flatness of the curves with increasing N/F) exclusively at the expense of substantially higher N/F. Higher power loading is possible by installing more powerful engines, thus N/F was raised from 10-12 hp/m² to 14-15 hp/m². Nearly all design types

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*The equation for v_{max} dependent on N/F and independent relative to flight weight is:

$$v_{max} = \sqrt[3]{\frac{2g}{\gamma} 75 \frac{N}{F} \left(\frac{\eta}{c_w}\right)_{max}}$$

The division of the influential factors likewise gives:

$v_{max} = k_2 \sqrt[3]{\frac{N}{F}}$, wherein factor k_2 contains the value

$\left(\frac{\eta}{c_w}\right)_{max}$, that is, the high-speed figure, and consequently also is a criterion for the aerodynamic quality.

have a figure of merit of around 100, with the exception of the BFW Me 108, which shows $k_2 = 120$ without, however, exceeding the value of the earlier type M 29 (1932).

TABLE I. Optimum k_1 for Different Entries in the 1934 Contest

Type	G/N kg/hp	v_{max} km/h	$k_1 = 75\,\eta\left(\frac{c_a}{c_w}\right)_{max}$
BFW Me 108	5.0	287.0	1435
Fi 97	5.0	243.0	1210
RWD 9	4.75	243.0	1160
Aero A 200	4.30	237.0	1025
PS 1	5.25	223.0	1170

Taken as a whole, the aerodynamic quality of this year's types is below the average of last year's contest.

Next to high speed, the low speed in horizontal flight is of decisive importance for the performance appraisal. To simplify the landing conditions, the landing speed shall be as low as possible. As a result, the excellence of an airplane is solely defined by the ratio of its high to low speed (v_{max}/v_{min}), which should be as high as possible.

The factors governing this ratio, aside from the aerodynamic performance coefficients, are η/c_w and $c_{a_{max}}$, represented in combination with figure of merit k_3*

*The speed range conforms to

$$\frac{v_{max}}{v_{min}} = \frac{k_2 \sqrt[3]{N/F}}{\sqrt{\frac{2g}{\gamma}\,\frac{1}{c_{a_{max}}}\,\frac{G}{F}}} = \frac{k_3}{\sqrt[3]{\frac{G}{N}}\sqrt{\frac{G}{F}}}$$

The factor k_3 obtained after dividing the different influential factors again defines the aerodynamic quality, because it essentially contains η/c_w and $c_{a_{max}}$.

the design factor $\left(\frac{G}{N}\sqrt{\frac{G}{F}}\right)$ as the common factor of power loading and wing loading.

TABLE II. Optimum k_2 Values

Type	N/F	v_{max}	k_2
BFW Me 108	14.4	291.0	120.0
Fi 97	13.7 to 15.0	243.0	102.0
RWD 9	13.8 to 16.3	243.0	101.5
Aero A 200	13.3	237.0	100.0
PS 1	11.4	223.0	99.0

Figure 23 illustrates the relationship between v_{max}/v_{min} and the design factor, the plotted boundary curves being valid for an equal degree in k_3. Their shape manifests the amount of necessary reduction in design factor to assure a higher v_{max}/v_{min} ratio for k_3 = constant.

TABLE III. Optimum k_3 Values

Type	$\frac{G}{N}\sqrt{\frac{G}{F}}$	v_{max}/v_{min}	k_3
BFW Me 108	31.0	4.6	14.15
Fi 97	33.0	4.15	13.20
RWD 9	28.5	4.70	14.10
Aero A 200	30.0	4.25	13.30
PS 1	35.0	3.42	11.15

As a result of the sweeping application of the latest auxiliary means, high-speed ratios of 4.0 and more have been obtained and this applies to all entries with few exceptions. The best figures here were those of the already cited BFW Me 108 and the winning airplane, the RWD 9 (see table III). But taken as a whole, there is no such abrupt rise in aerodynamic quality as evinced in the preceding contest.

So one may perhaps be tempted to deny any marked advance from the aerodynamic point of view, especially when compared to the substantially greater progress shown in the preceding years. Nothing was left undone this year; every conceivable modern means and method were used to raise the aerodynamic quality. And so rather than deny all progress, one should ask how far - judged by the present stage of engineering - we actually are from the practically attainable limit of advance.

To illustrate: Comparing the types developed by the BFW for the past races, the BFW Me 108 reveals no marked improvement in aerodynamic quality as shown by the M 29, for instance. The added rise in high speed was largely due to higher power loading and wing power, i.e., by using more powerful engines. The wing loading was changed scarcely at all. But to deny, on the strength of this, that every conceivable means had been utilized which constitutes aerodynamical advance, would be unjustified. For example, the BFW Me 108 was fitted with retractable landing gear, wing fillets - in short, every conceivable improvement was resorted to, to minimize parasitic drag, especially drag due to mutual interference. A better propeller efficiency resulting from the use of engines with high reduction gear ratio (low propeller r.p.m.) may also be assumed for the majority of airplanes. The reason why all these attempts failed to equal the degree of advance of the preceding years lies elsewhere.

According to present-day contest regulations, the type M 29 is in no way a general-purpose airplane - either in design or construction. On the contrary, the BFW Me 108 is, rather, the first airplane ever to embody improvements which enhance its usefulness as a touring plane, particularly as concerns cabin and seat arrangement, and general body design. Proof of the superiority, for instance, of the German types, especially the BFW Me 108, in this respect, is shown by the fact that in the rating of the technical qualities, the German entries scored the highest points. Since this system of scoring comprises the judgment of all countries participating in the contest, it at the same time means that these countries are unaninously of the opinion as to what a touring airplane should be. The increased fuselage size necessary to meet these demands (greater cross-sectional area) entail a not inconsiderably higher body drag - not in the least for the reason that the part of the equivalent flat-plate area exposed to the slipstream had been increased, aside from the effect on the propeller efficiency.

A comparison of the speed performances must also take into consideration the fact that several of the German entries - to remain within the stipulated weight limit - had to remove various drag-reducing devices, such as wheel fairings, prior to the technical trials, and thus knowingly lose certain points of decisive importance for the evaluation of the aerodynamic quality. In addition, the use of new aileron design types (as on Fi 97, for instance) and certain auxiliary means for raising the lift maximum, necessitated the fitting of guides and controls on the wing structure, which could not be housed away from the wind. Of course, much improvement is expected for reducing the drag at high speed.

On the other hand, the modern means for increasing the maximum lift and the gliding angle at high angles of attack have been fairly exhaustively and comprehensively utilized. There is the almost universal use of the slotted wing (Handley Page-Lachmann), usually in combination with trailing-edge flaps of simple and special design, as shown elsewhere in the report.

From the results of the slow speed trials, the maximum c_a values obtained with these high-lifting devices have been computed and tabulated in table IV. The obtained optimum values always serve as a basis. The propeller-thrust effect whose vertical component is not inconsiderable at high angles of attack has, of course, not been considered. But this omission here is so much more legitimate as the conditions for this were similar in all airplane types. Therefore the figures are perfectly satisfactory for comparative purposes, even though the absolute values may be too high. Taken as a whole, the highest c_a reached are by no means higher than those of 1932, in spite of the promise held out by the use of the very latest high-lifting devices. Contrariwise, the $c_a = 3.55$ obtained with the RWD 9, is remarkable.

TABLE IV. Power Factors, Optimum High and Low Speed and c_a Factors of the 1934 International Touring Competition Entries*

Type	Wing area G/F[1] kg/m^2	Low speed v_{min} km/h	c_a values[2] reached	b^2/F^3	G/b^2	High speed v_{max} km/h	$\frac{v_{max}}{v_{min}}$	Power loading G/N kg/hp	Design factor $GN \sqrt{G/F}$	Special devices
BFW Me 108	46.5	62.74	2.45	6.15	7.55	291	4.65	4.55 to 5.0	31.0 to 34.0	Slotted wing, area-increasing flap, interceptor
Fi 97	44.0	58.50	2.68	6.3	7.0	243	4.15	4.55 to 5.0	30.0 to 33.0	Part-span slot, area-increasing rolling wing
Kl 36	41.0	57.7	2.56	6.2	6.6	250[3]	4.30	4.55 to 5.0	29.0 to 32.0	Slots and flaps, aileron with downward setting
RWD 9	50.0	54.15	3.55	8.45	5.9	255	4.70	4.1 to 4.75	28.5 to 33.5	Slots and flaps, interceptor
PZL 26	49.0	60.60	2.77	6.65	7.4	-	-	3.8	26.5	Slots and split flaps
A 200	48.5	55.9	3.22	7.45	6.5	237	4.25	4.30	30.0	Slots and flaps, interceptor, downward aileron setting
PS 1	45.6	65.25	2.22	6.5	7.0	223	3.41	5.25	35.0	Slotted wings
BA 42	50.5	75.00	1.86	6.45	7.85	-	-	4.55	32.0	Fixed slots, flaps
Puss Moth	39.2	61.50	2.14	6.15	6.4	-	-	6.20	39.0	Slots, part-span flaps

[1] F, the greatest possible wing area obtainable in flight. G = 560 (tare weight) + 200 (useful load) + 40 (fuel, oil, parachute) = 800 kg flight weight in test.

[2] $\frac{\rho}{2g} = \sim \frac{1}{16}$.

[3] Not measured in contest; data from preliminary test.

*Compiled according to results of the technical trials.

Even with due allowance for the fact that other causes, such as lack of time for testing, as a result of which the German entries, among others, suffered so that the improvements which undoubtedly had been made, did not definitely show up in the results of the trials, the superior performance of the RWD 9 is attributable to a different fact, namely, that among other things the aspect ratio b^2/F also affords a comparative value for the aerodynamic quality. On comparison of these characteristics (see table IV), it is surprising to find that the RWD 9 discloses the much higher figure of 8.45 as compared with figures around 6.2 for the German entries. Admittedly, the lower aspect ratio of the German types is readily intelligible from other reasons; they belong to the low-wing cantilever design type in contrast to the high-wing externally braced design of the RWD 9. Consequently, the lower aspect ratio is first of all determined from the consideration of strength requirements of the wing structure. Added to that, the G/b^2 factor*, that is, the spanwise loading of the German entries with 6.6 to 7.55 is substantially higher than for the RWD 9 with its 5.9. The lower this G/b^2 is, the greater is the power input for the design of the wing.

Another point worth mentioning on the subject of high- or low-wing airplanes is, that practical experience reveals the high-wing type to be far less subjected to downwash effects, body-wing effects, slipstream-wing-tail surface effects, and blanketing of tail surfaces at high angles of attack than the low-wing type. For this reason the high-wing is usually superior to the low-wing type in longitudinal stability. By virtue of its flight qualities, the high-wing type is able to maintain equilibrium position near the stall more readily than the low-wing type. The demands on the pilots flying a low-wing monoplane were consequently much more exacting than on the pilots flying high-wing monoplanes, without in any way attempting to detract from the skill of any of the pilots.

Translation by J. Vanier,
National Advisory Committee
for Aeronautics.

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*G/b^2 is the spanwise loading. This, together with the smallest (i.e., best ϵ) is decisive for the sinking speed; that is, the specific minimum power required of the airplane (power required to float in mkg/s referred to 1 kg flight weight).

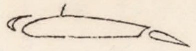
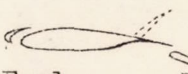
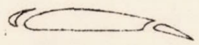
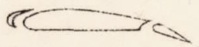
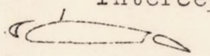
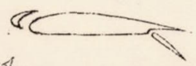
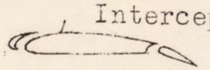
Airplane	Engine	Wing type H.P. slots flaps % of span	$\frac{N}{F}$	$\frac{G}{F}$	$\frac{\eta}{c_w}$	$c_{a_{max}}$	$\frac{v_{max}}{v_{max}/v_{min}}$
Messerschmitt	Hirth HM 8 Arg. As 17	Interceptor  44% automatic 38% mechanical 69%	$\frac{14.4}{13.8}$	47.5	$\frac{30.5}{31.5}$	2.5	$\frac{1.29}{1.3}$
Fieseler 97	Hirth HM 8 Arg. As 17	 55% Fowler 77%	$\frac{15.1}{14.4}$	50	$\frac{17.1}{17.8}$	3.05	$\frac{1.32}{1.33}$
Klemm 36	Hirth HM 8 Arg. As 17	 84% 38%	$\frac{11.8}{11.3}$	39	$\frac{12.0}{12.5}$	2.45	$\frac{-}{-}$
PS 1	Fiat A 70 S	 77% 77%	12.5	43.5	15.9	1.41	1.41
Aero 200	Walter-Bora	Interceptor  78% 85%	12	46	20	3.07	1.31
PZL 26	Menasco Bucc. B 6 S	 95% 84.7%	16.4	46.3	28.6	2.43	1.34
RWD 9	Skoda Gr.760 Walter-Bora	Interceptor  73.3% 85.6%	$\frac{17.5}{12.5}$	47.5	$\frac{18.8}{20.6}$	3.38	$\frac{1.29}{1.27}$

FIGURE 3.-Comparison of the airplanes, with indications of the lift-increasing device, prepared by Eng. B. Werner, of the Polish Institute for Aeronautical Research, Warsaw.*

*From Aircraft Engineering, October 1934, page 260.

Figure 1a.-The BFW Me 108 airplane.

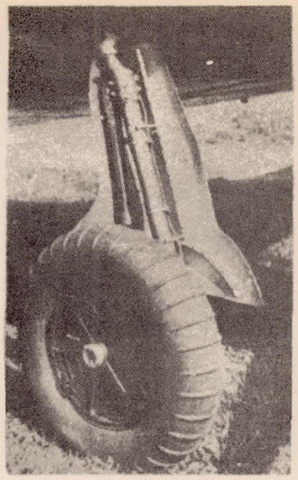


Figure 1b.- Landing gear of the Me 108.

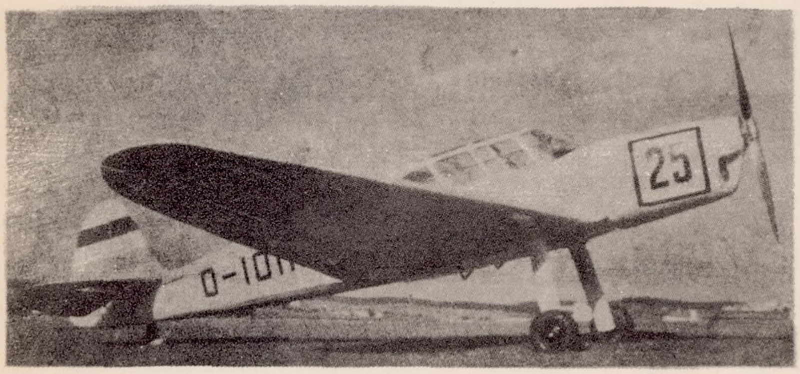


Figure 2a.-The Klemm Kl 36 airplane.

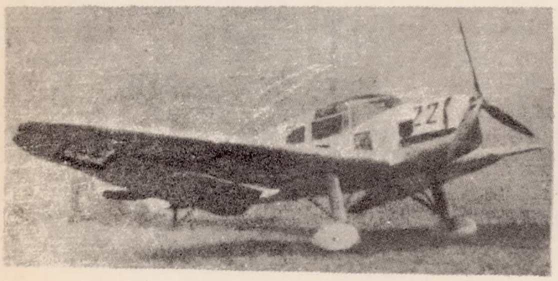


Figure 3a.-The Fieseler Fi 97.

Figure 4a.-The RWD 9 airplane.

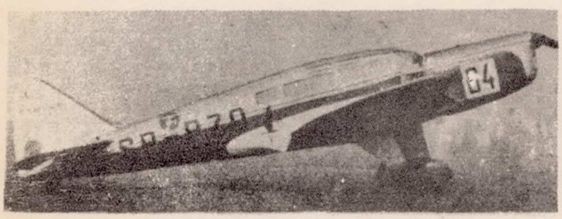


Figure 5a.-The PZL 26 airplane.

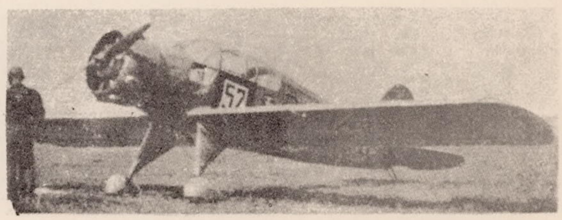


Figure 6a.-The Aero A 200 airplane.

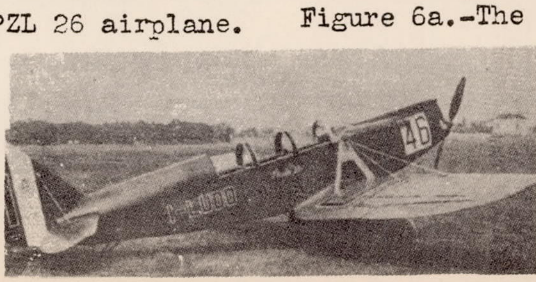
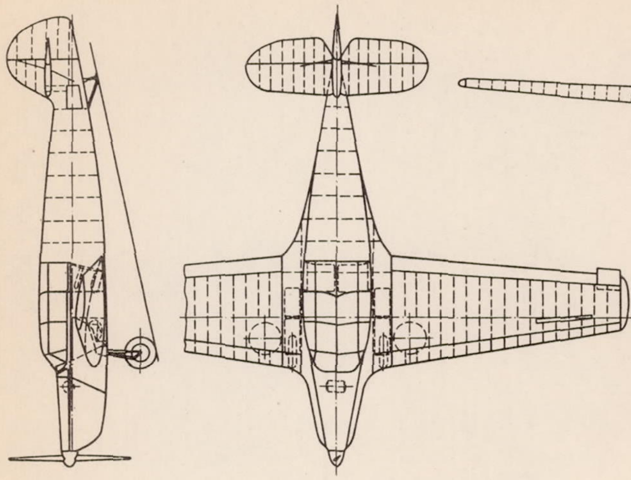
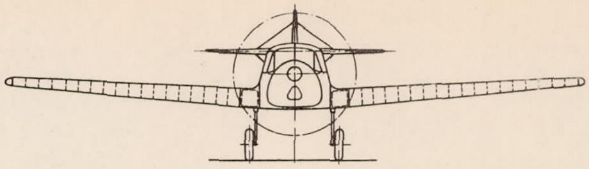
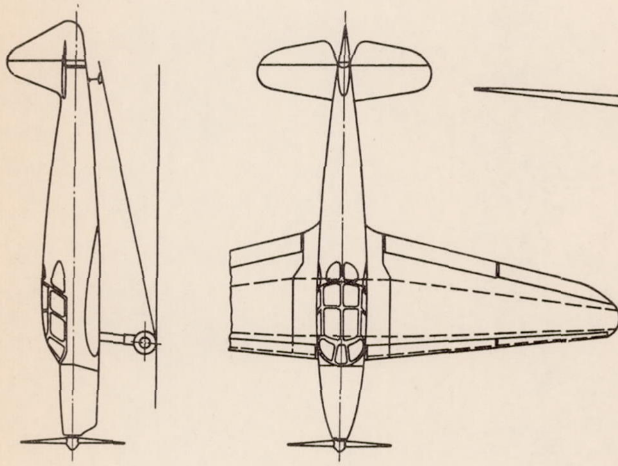


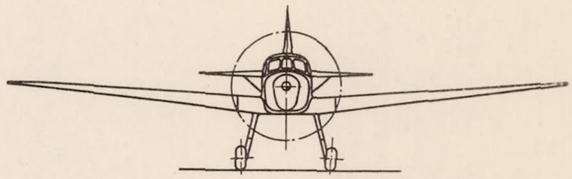
Figure 7a.-The Breda BA 39S airplane.



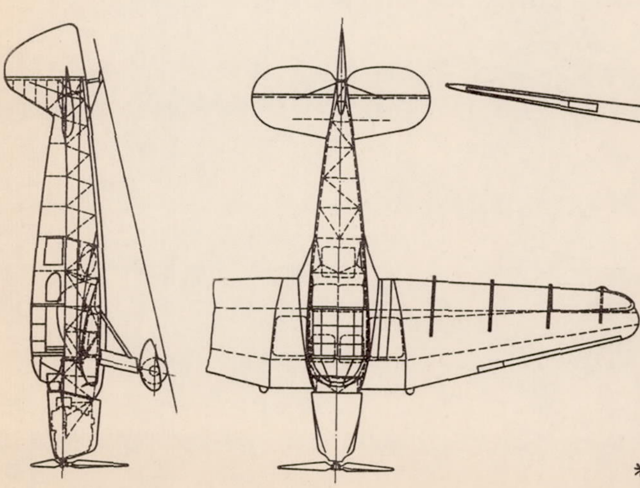


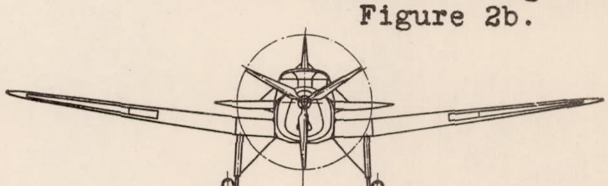
BFW Me 108
Computed performance with
Hirth HM 8 U engine
Maximum speed.186.4 m.p.h.
* Stalling " ...37.3 "
Flight range..435.0 miles
* With 1720 lb..flight wt.
Figure 1c.





Klemm Kl 36
Computed performance with
Hirth HM 8 U engine*
Maximum speed.155.3 m.p.h.
Stalling " ...34.2 "
Climb to 3280 ft. 3.4 min.
Service ceiling 19,000 ft.
Flight range..559.2 miles
* With 2315 lb. flight wt.
Figure 2b.





Fieseler Fi 97
Computed performance with
Hirth HM 8 U engine*
Maximum speed.161.6 m.p.h
Stalling " ...34.8 "
Initial rate
of climb.19 ft./sec.
* With 2315 lb. flight wt.
Figure 3b.

Figures 1c.2b.3b. The German entries

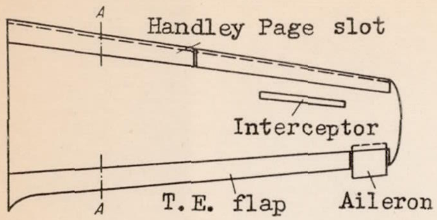
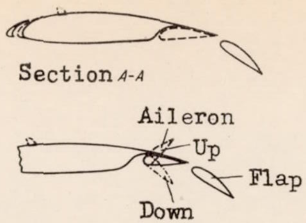


Figure 1d



BFW Me 108

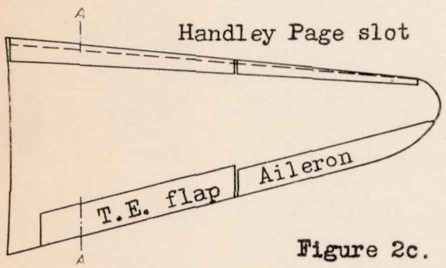
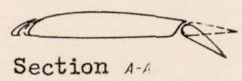


Figure 2c.



Klemm Kl 36

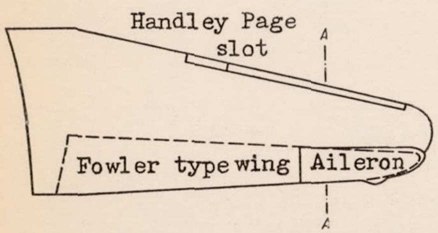
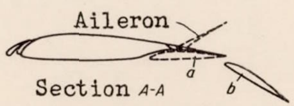


Figure 3c.



a, retracted
b, extended

Fieseler Fi 97

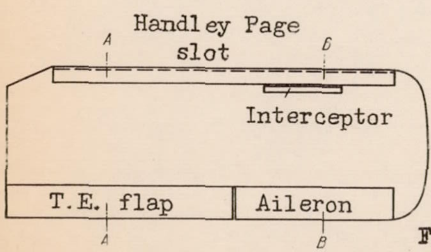
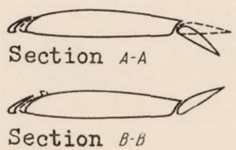


Figure 4b.

RWD 9



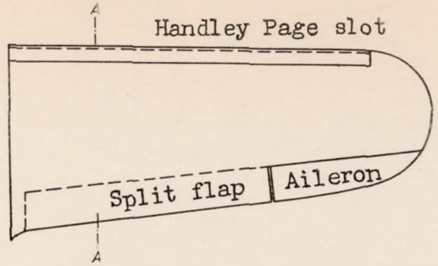
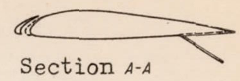


Figure 5b.



PZL 26

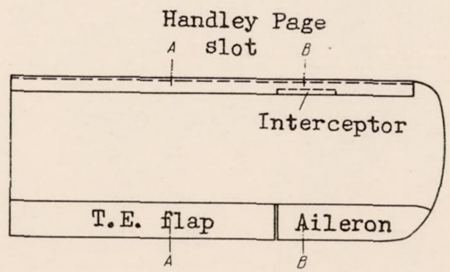
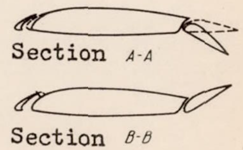
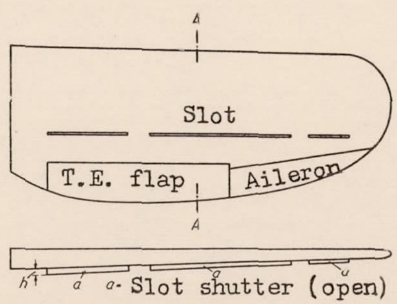


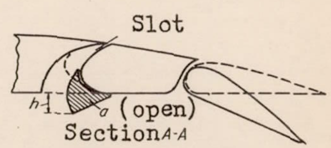
Figure 6b.



Aero A 200

Drawings not to scale





Breda BA 39 S und
Breda BA 42

Figures 7b,8b.

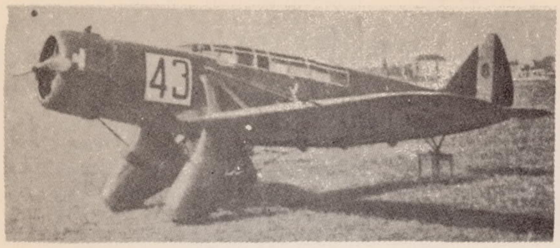


Figure 8a.-The Breda BA 42 airplane.

Figure 9a,-The Bergamo PS 1 airplane.

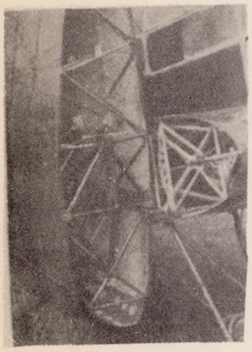


Figure 9b.- Folded wing of the PS 1..

Figure 10.- Folded wing of the Kl 36.

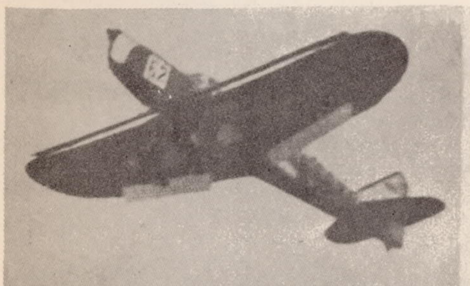


Figure 11.- The PZL 26 airplane in stalling flight.

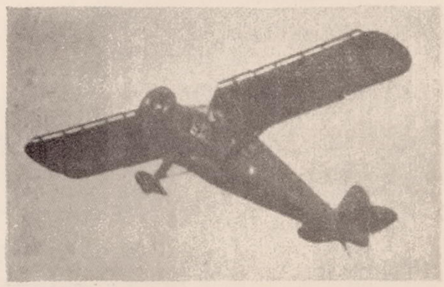


Figure 12.- The RWD 9 airplane in stalling flight.

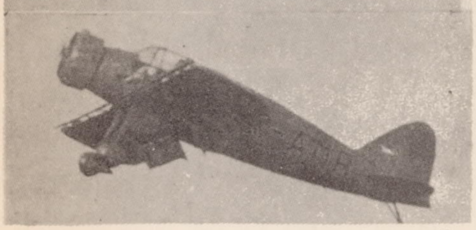
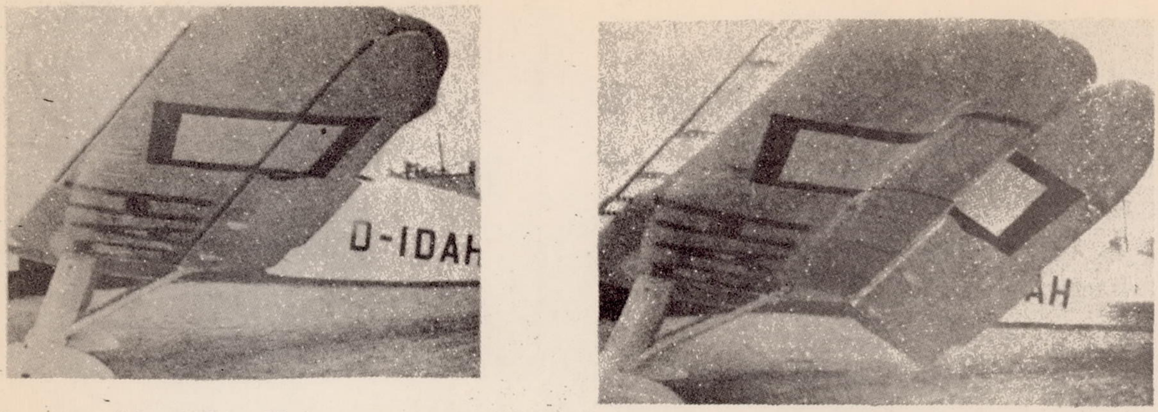


Figure 13.-The Aero A 200 airplane in stalling flight.

Figure 14.-Interceptor of the Aero A 200 airplane.

Figures 15a,15b.-Closeup of wing surfaces of the BFW Me 108 airplane.



Figures 16a,16b.-Closeup of wing surfaces of the Fieseler Fi 97 airplane. At left, Fowler wing rolled in with slot closed.

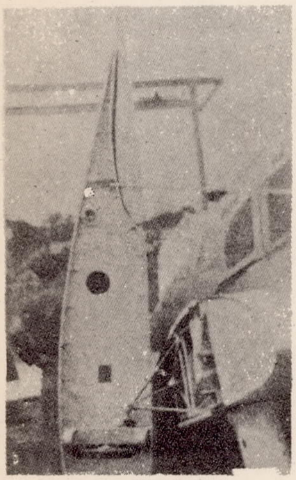


Figure 17.-Folded wing of the Fi 97.

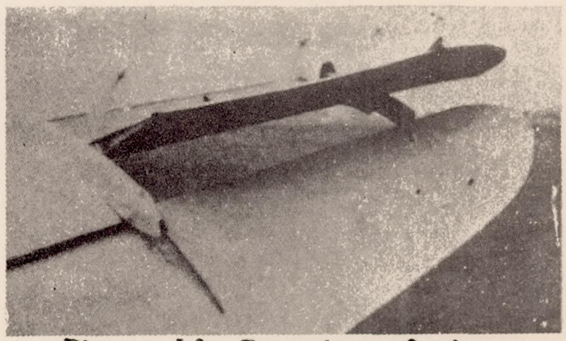


Figure 18.-Top view of wing surfaces of the Fi 97 airplane, aileron up, auxiliary wing wholly out.

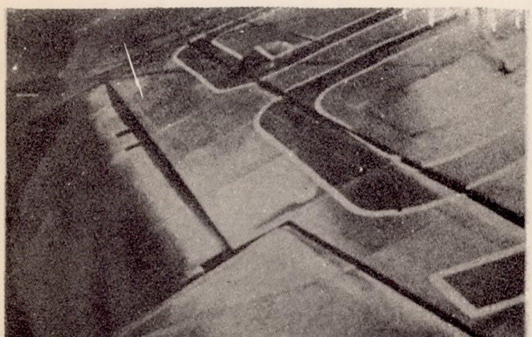


Figure 19.-Top view of wing surfaces of the Breda.

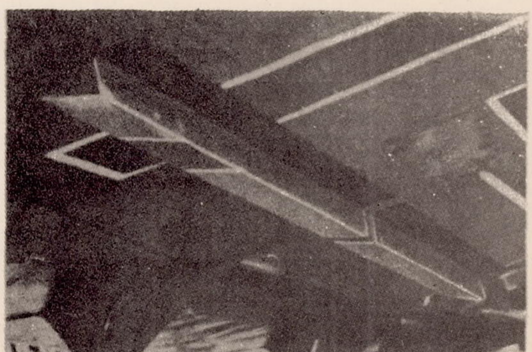


Figure 20.-Under side of the Breda wing, slot cover open.

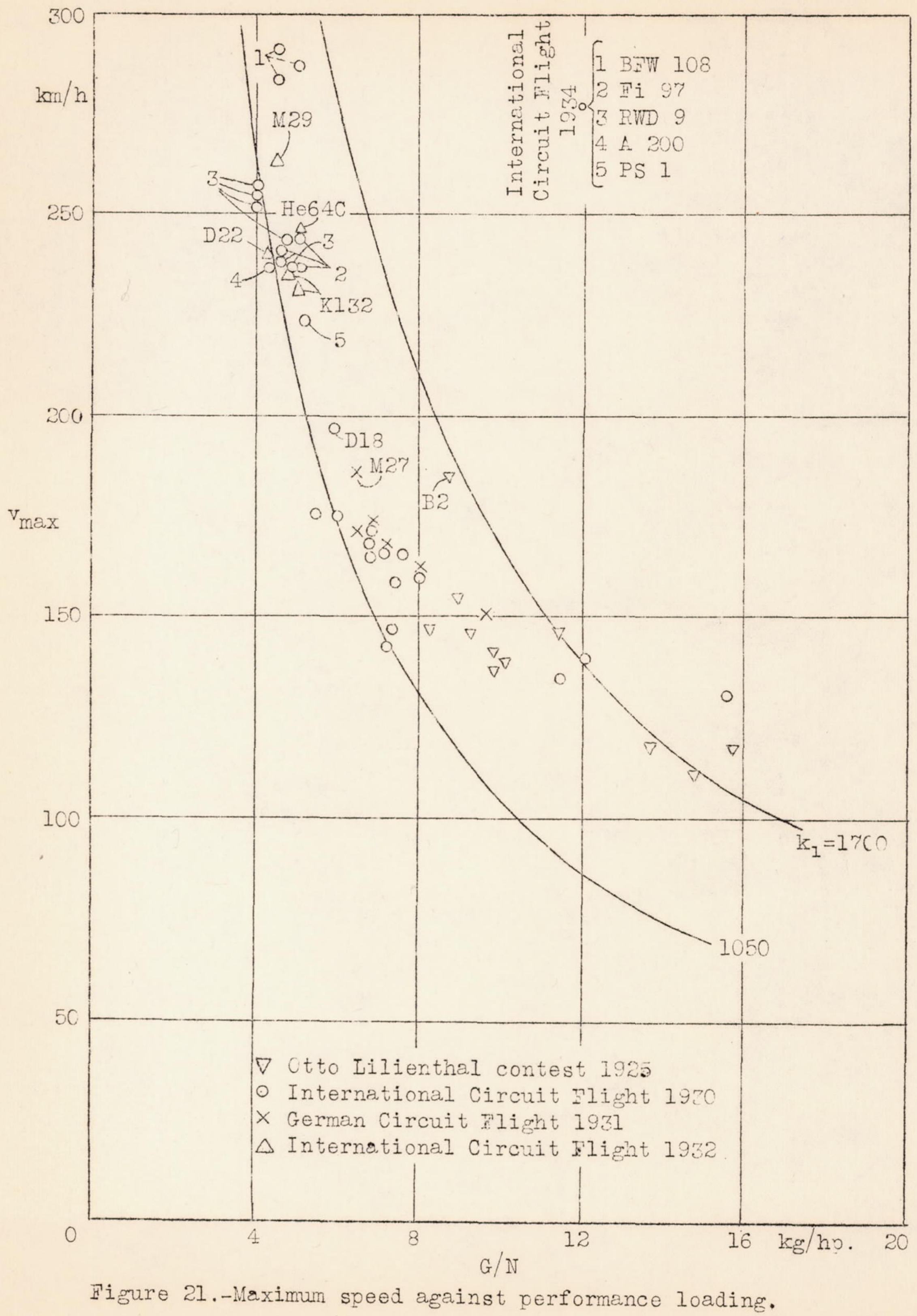


Figure 21.-Maximum speed against performance loading.

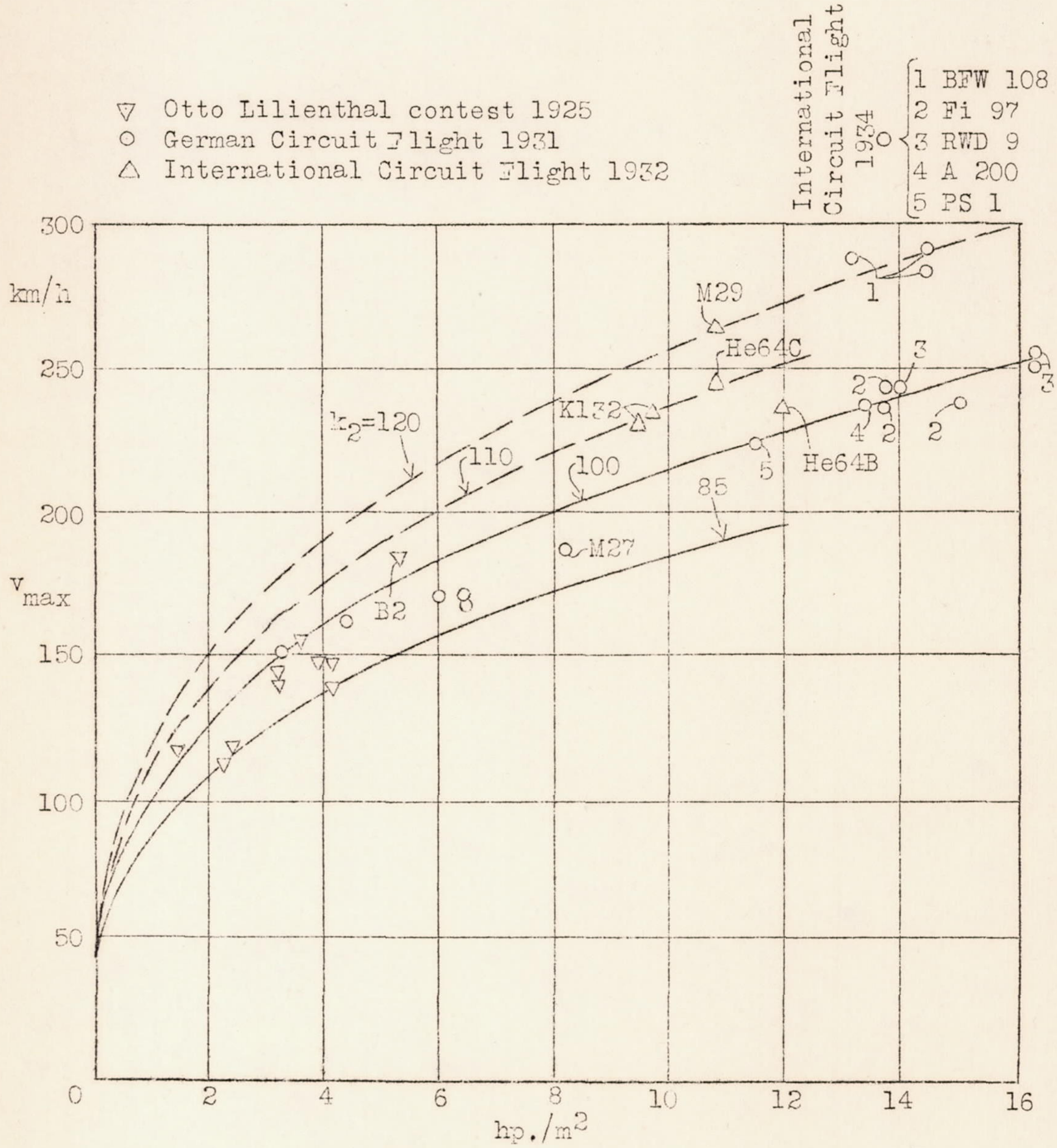


Figure 22.-Maximum speed against power loading.

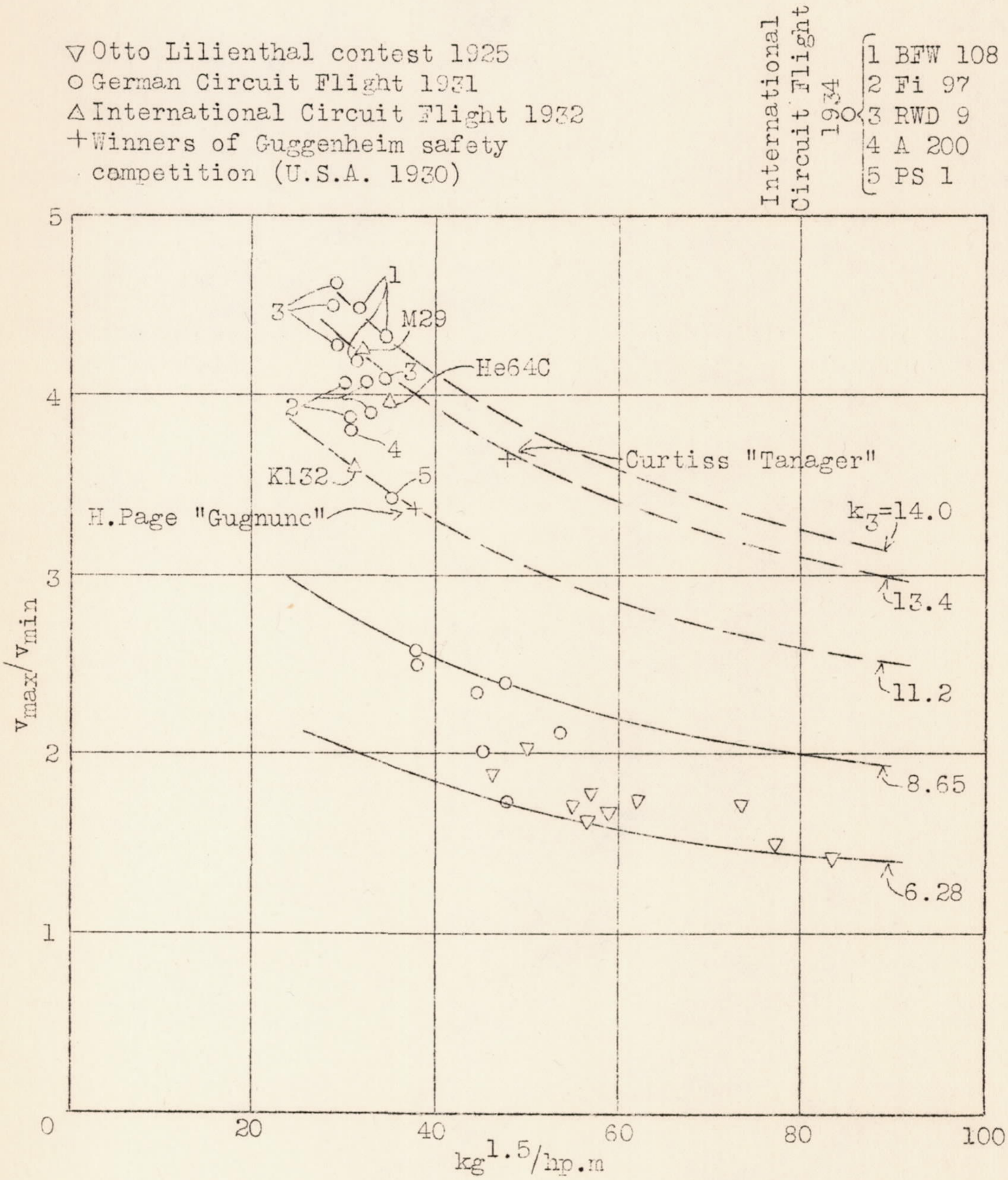


Figure 23.-Speed ratio against design factor.